

MODIS

Science Data Processing Software

Version 1 Requirements Specification



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MODIS
Science Data Processing Software
Version 1 Requirements Specification

Prepared By:

<hr/> Frederick S. Patt, SAIC/GSC SDST Systems Analyst	Date
---	------

Reviewed By:

<hr/> Dr. Wayne Esaias, GSFC/Code 971 MODIS STM Oceans Group Leader	Date
--	------

<hr/> Dr. Robert Evans, University of Miami MODIS STM Oceans Data Systems	Date
--	------

<hr/> Dr. Al Fleig, University of Maryland Data System Scientist	Date
---	------

<hr/> Dr. Chris Justice, University of Maryland MODIS STM Land Group Leader	Date
--	------

<hr/> Dr. Youram Kaufman, GSFC/Code 913 MODIS STM Atmospheres Group Leader	Date
---	------

<hr/> Barbara Putney, GSFC/Code 920 MODIS Systems Engineer	Date
---	------

Reviewed By:

James Firestone, SAIC/GSC
STTG Lead

Date

Laurie Schneider, SAIC/GSC
SDST R&QA Manager

Date

Dr. Bruce Guenther, GSFC/Code 925
MODIS MCST Task Leader

Date

Dr. Richard Isaacman, SAIC/GSC
MODIS SDST Task Leader

Date

Approved By:

Edward Masuoka, GSFC/Code 920.2
MODIS SDST Manager

Date

Change Record Page

This document is baselined and has been placed under Configuration Control. Any changes to this document will need the approval of the Configuration Control Board.

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MODIS

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1. INTRODUCTION

1.1 Purpose

This document is the requirements specification for the Version 1 (V1) Release of the Moderate Resolution Imaging Spectroradiometer (MODIS) Science Data Processing Software (SDP S/W) system. The V1 Release shall be integrated in the MODIS Team Leader Computing Facility (TLCF) at Goddard Space Flight Center (GSFC) and migrated to the EROS Data Center (EDC) Distributed Active Archive Center (DAAC), National Snow and Ice Data Center (NSIDC) DAAC (if available in Release A), and the GSFC DAAC. The Team Leader Working Agreement (TLWA) serves as the parent document for this requirements specification. As defined by the TLWA, the programs in the V1 delivery shall demonstrate all major functional capabilities and a complete operator interface, including the generation of all needed messages using standard error and message services. V1 shall require realistic computational resources, near those of Version 2 (V2), the launch-ready system.

1.2 Scope

This document identifies the requirements on all of the software elements comprising the MODIS V1 Release of the SDP S/W. The major software elements provided by the Science Data Support Team (SDST) and the MODIS Characterization Support Team (MCST) include:

- Level 1A (L1A) and Geolocation Processing Software
- Level 1B (L1B) Processing Software
- Product Generation Executable (PGE) scripts
- MODIS-Application Program Interface (M-API) utilities

The major software elements provided by the Science Team Members (STM) include:

- Level 2 (L2), Level 3 (L3), and Level 4 (L4) software processes
- Gridding and binning utilities
- Cloud masks
- Production Rules for PGE initiation

1.3 Version 1 Goals

The overall goals for the V1 Release of the MODIS SDP S/W are:

- Demonstrate that the V1 software developer has delivered working code that ingests simulated MODIS instrument data, or data derived from simulated MODIS instrument data.
- Demonstrate that working code which generates all at-launch products has been delivered.
- Demonstrate that the V1 software processes have been adequately tested both individually (unit test) and in complete processing strings in both nominal and exception situations and that a complete test, result tracking and documentation process is in place.
- Employ the full set of ancillary data sets required by the V1 software processes. Use actual examples of the ancillary data as provided by the organization responsible for producing the ancillary data set. Ingest the ancillary data as it will be produced and interpolate or otherwise manipulate it to get the values at pixel locations as needed by the V1 algorithm.
- Demonstrate that all software ingests, evaluates, and responds appropriately to all of the error and quality flags that can be present in all inputs (MODIS radiances, predecessor algorithm outputs and ancillary data).
- Baseline the Hierarchical Data Format (HDF) file specification for each MODIS at-launch product.
- Demonstrate use by MODIS Science Software of the HDF-Earth Observing System (EOS) constructs and utilities.
- Identify the spatial and temporal dependencies between MODIS products and software processes needed to integrate the processes into the expected at-launch threads of execution and to provide the necessary Level 1 (L1) test data sets to test these dependencies.
- Prototype multigranule, multiprocessing execution.
- Exercise the scheduling software chosen for the DAACs to verify that it meets MODIS's requirements and functions properly in the MODIS processing context.
- Demonstrate that the V1 software generates appropriate Quality Assurance (QA) flags, warnings, operator messages and metadata and continues to process subsequent pixels when presented with defective inputs and/or radiances which are inconsistent with anticipated values.
- Test all V1 software and processing threads under both normal operation and exception-handling scenarios.
- Provide accurate estimates of the computing resource requirements and output volumes of at-launch MODIS products based on actual software timing.

1.4 Content and Structure

This document's structure was derived from NASA-STD-2100-91 and is organized into the following sections:

- Section 1 provides the background and introduction to this document.
- Section 2 details the system-level requirements for V1.
- Section 3 details the process-specific requirements.
- Section 4 identifies product-specific requirements.
- Section 5 identifies PGE requirements.
- Section 6 identifies testing requirements.
- Section 7 identifies operational requirements.
- Section 8 identifies the acronyms and abbreviations.

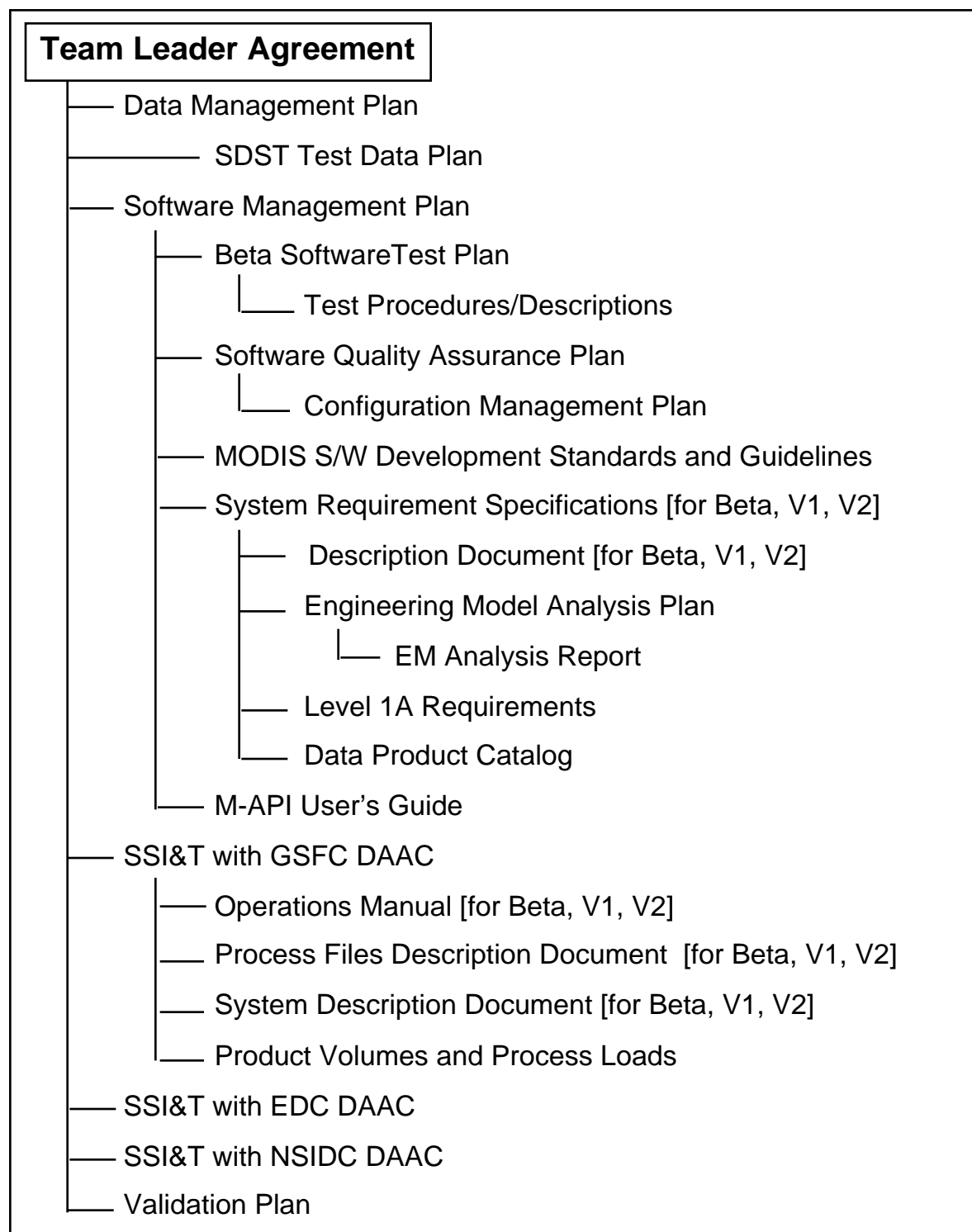
1.5 Relevant Documents

The following documents serve to provide information relevant to the MODIS V1 Requirements Specification document:

- MODIS Software Management Plan; October 24, 1995; SDST-002.
- MODIS Data Management Plan; October 25, 1995; SDST-006.
- MODIS Operations Concept Document-Version 1, SDST, August 1993.
- MODIS Software Development Standards and Guidelines, Version 1; SDST-022 (Change 1); October 25, 1995.
- M-API User's Guide, Version 1.1; P600-CD-001-002; June 19, 1995.
- MODIS Product Volumes and Process Load Estimates; SDST-009; August 11, 1995.
- MODIS Version 1 Test Plan; TBD; SDST-060.
- MODIS Version 1 Processing Files Description Document; TBD; SDST-061.
- Science Software Integration and Test Procedures for the MODIS Instrument at the GSFC DAAC; September 1995; SDST-017.
- Data Production Software (DPS) and Science Computing Facility (SCF) Standards and Guidelines; January 1994.
- EOS Reference Handbook.
- ICD Between EOSDIS Core System (ECS) and SCF-Prelim. (209-CD-005-001), 1/95
- Science User's Guide and Operations Procedure Handbook for the EOS Core System (ECS) Project, Part 4: Software Developer's Guide to Preparation, Delivery, Integration, and Test with the ECS; 205-CD-002-002; Final, August 1995.
- SDP Toolkit User's Guide for the ECS Project; August 1995; DID 333-CD-003-002.
- Science Processing Support Office (SPSO) Product Database.

- Team Leader Working Agreement for MODIS Between EOS AM & PM Projects GSFC and the MODIS Science Team Leader; GSFC 421-12-14-02; April 21, 1994.
- Science Data Processing Segment (SDPS) Database Design and Database Schema Specification for the ECS Project”, DID 311-CD-002-002.

Figure 1-1 shows the documentation tree for the documents developed (or to be developed) by the SDST for the MODIS Team Leader. This figure shows the relationship between the TLWA and MODIS Project documentation.

**Figure 1-1 MODIS Documentation Tree**

2. VERSION 1 SYSTEM-LEVEL REQUIREMENTS

2.1 External Constraints

This section describes the assumptions and dependencies affecting the MODIS SDP S/W for the V1 Release.

- The MODIS SDP S/W depends on ECS to provide the following capabilities implemented in Science Data Production Toolkit (SDPTK) routines:
 - Access to solar system object positions
 - Values of mathematical and physical constants
 - Access to ECS-provided ancillary data
- The ECS SDPTK does not currently support running on the Silicon Graphics, Inc. (SGI) Power Challenge in native (n32 or 64-bit) mode. SDST is relying on ECS to provide this capability in Toolkit Version 5.1, supported under IRIX 6.2, by the agreed date of July 31, 1996.

2.2 Configuration Control

Configuration control requirements have been deleted.

2.3 Interface Requirements

- 2.3-1 Each software process within the MODIS V1 SDP S/W system shall employ the Earth Science Data and Information System (ESDIS)-supplied SDPTK Version 5.1 mandatory functions to access the DAAC production environment and services. The mandatory functions include generic file Input/Output (I/O), metadata, error message transaction, process control, spacecraft ephemeris and attitude, and time and date transformations (DID 333-CD-003-002, August 1995, Section 4.1).
- 2.3-2 Each software developer, with the help of the Science Software Transfer Group (SSTG), shall provide an HDF file description for the archivable MODIS product(s) produced by their software. This specification shall describe the structure and format of the HDF data objects in the files down to the bit level. This specification shall be provided to the SDST CMO prior to the delivery of the software to the SDST SSTG. The specification will be baselined, with all further changes subject to approval by the SDST Configuration Control Board.
- 2.3-3 Deleted.
- 2.3-4 Deleted.

- 2.3-5 The numbering scheme for the Process Control File (PCF) logical numbers used by the software processes to obtain data from the SDPTK shall follow a consistent convention to be defined by the SDST, and shall not conflict with the range of logical numbers reserved for use by the Toolkit routines (10,000 - 10,999).
- 2.3-6 The numbering scheme for the Status Message Facility (SMF) seed numbering assignments used by the software processes to log error messages to the SDPTK shall follow a consistent convention to be defined by the SDST, within the range of values assigned by ECS to MODIS (35,000 - 39,999).

3. VERSION 1 SOFTWARE PROCESS REQUIREMENTS

3.1 Process Definitions

- 3.1-1 A software process is defined as any element of executable software listed in Table 3-1.
- 3.1-2 The software processes listed in Table 3-1 are the complete set of processes that shall be incorporated in the V1 Release.
- 3.1-3 The output of the V1 software processes shall be consistent with the MODIS Data Product Catalog, which is available on-line at Universal Resource Locator (URL) <http://modarch.gsfc.nasa.gov/MODIS/DATAPROD/dataprodcatalog.html>.

3.2 Process Interface Requirements

- 3.2-1 Each software process in the V1 release shall be capable of being ported to and running in native (n32 or 64-bit) mode on an SGI platform under the IRIX 6.2 operating system.
- 3.2-2 Processes requiring HDF utilities to produce data files shall use HDF Version 4.0.

3.3 Process Coding Standards

- 3.3-1 Each software process shall be coded according to the standards specified in the most recent baselined version of the MODIS Software Development Standards and Guidelines, Version 1, SDST-022 .

3.4 Process Reliability Standards

- 3.4-1 The MODIS processing software shall trap and properly process all exceptions that may produce an abort condition and report all such events to the message log files.
- 3.4-2 The MODIS processing software shall terminate gracefully upon detection of a non-recoverable error condition.
- 3.4-3 Deleted.
- 3.4-4 Each software process in the MODIS SDP S/W V1 system shall demonstrate the ability to process input test data sets with the following attributes:
 - 3.4-4.1 Missing data, including missing pixels, missing bands, and/or missing scans marked by the appropriate fill data.
 - 3.4-4.2 Redundant data, consisting of repeated packets at Level 0.
 - 3.4-4.3 Noisy or corrupted data as indicated by QA flags also located within the file.

- 3.4-4.4 Time transitions, including Greenwich Meridian crossing, International Data Line crossing, leap year, beginning of the year, and/or start of data collection not on a granule boundary.
- 3.4-4.5 Terminator crossings.
- 3.4-4.6 Night mode data.
- 3.4-4.7 Missing input MODIS Product files, ancillary files, and Look-up Tables (LUT).
- 3.4-4.8 Wrong format input files.

Table 3-1 MODIS Software Process Definition

(Insert Table 3-1)

4. SCIENCE DATA PROCESSING SOFTWARE PRODUCT REQUIREMENTS

4.1 Product Definitions

- 4.1-1 A MODIS product shall be defined as any data file identified with a Product ID in Table 3-1.
- 4.1-2 The definition of the level of a given product shall adhere to Table 4-1, MODIS Data Level Definitions.
- 4.1-3 One or more MODIS standard products defined in Table 3-1 shall be stored in HDF-EOS file structures.
- 4.1-4 No HDF product file shall exceed two gigabytes in size for the V1 Release.
- 4.1-5 All bit data within a product (QA information, masks, flags, etc.) shall be designed to fall within byte boundaries.

Table 4-1 MODIS Data Level Definitions

Data Level	Data Definition
Level 0	Instrument data at original resolution, time ordered restored, with duplicate packets removed.
L1A	Level 0 data which are reformatted with calibration data and other ancillary data included. Geolocation information for each 1 km spatial element of the reformatted swath data will be stored as a separate product.
L1B	L1A data to which the radiometric calibration algorithms have been applied to produce radiances or irradiances.
L2	Geophysical parameter data retrieved from the L1B data by application of geophysical parameter algorithms.
L3	Earth-gridded geophysical parameter data, which have been averaged, gridded, or otherwise rectified or composited in time and space.
L4	Model output or results of analysis from lower level data, for example variables derived from multiple measurements.

4.2 Product File Naming Conventions

Product file naming conventions are necessary to allow users of MODIS archived products to search and retrieve data file lists from ECS without having to open each file and read extensive amounts of metadata in order to understand the contents.

- 4.2-1 The SDST shall define a consistent naming convention of the MODIS Product Files.

4.3 Metadata Requirements

- 4.3-1 Each MODIS Standard Product (as defined in Table 3-1) shall contain ECS core metadata as specified in DID 311.
- 4.3-2 The fields making up the core metadata shall have the same definition and range of values across all MODIS data products.
- 4.3-3 Each MODIS Standard Product shall contain product-specific metadata.
- 4.3-4 The product-specific metadata shall have fields that are specific to a given data product or group of products.
- 4.3-5 The information comprising the Metadata Configuration File (MCF), as defined in the SDPTK User's Guide shall be provided by each product's developer.

4.4 Product Gridding, Tiling, and Geolocation

4.4.1 Product Gridding Requirements

- 4.4.1-1 The MODIS L3 and L4 products shall be produced on a Binned Sinusoidal grid, which is an equal area grid.
- 4.4.1-2 A spherical shape shall be assumed for the Earth when making a sinusoidal projection.
- 4.4.1-3 The spatial starting points for all grids shall be defined such that vertically (latitudinal) the bottom of the first row of cells in the Northern hemisphere will touch the equator and horizontally (meridional) the left edge of the first cell on the left at the equator will be at 180 degrees West longitude.
- 4.4.1-4 The allowed grid resolutions for climatological modeling shall use an equal angle grid at 1.0 degree (111 km), 0.5 degree (57 km), and/or 0.25 degree (28.5 km) resolution.

4.4.2 Tiling Requirements

Deleted

4.4.3 Geolocation System-Level Spatial Requirements

- 4.4.3-1 The MODIS geolocation process shall generate Earth locations for each 1 km spatial element.
- 4.4.3-2 The Earth locations shall consist of geodetic coordinates (latitude, longitude, and height), satellite vectors (zenith, azimuth, and range), solar vectors (zenith and azimuth), and quality flags.

- 4.4.3-3 The MODIS geolocation process shall have an absolute Earth location accuracy of 0.1 (2 sigma) Instantaneous Field-Of-View (IFOV) for the nominal 1 km resolution bands, with respect to the World Geodetic System 84 (WGS84) reference frame.
- 4.4.3-4 The MODIS geolocation process shall compute the azimuth and elevation of the Sun relative to the plane containing the surface of the solar diffuser and relative to the scan plane as defined in MODIS centered coordinates, at the time of the center frame of the solar diffuser view sector.
- 4.4.3-5 The MODIS geolocation process shall compute the satellite-to-Moon center unit vector in MODIS instrument coordinates, at the time of the center frame of the Space view sector.

4.5 Quality Assurance Flag Requirements

- 4.5-1 Each MODIS Standard Product (as defined in Table 3-1) shall contain appropriate QA flags which shall indicate the quality of the input data and the product fields.
- 4.5-2 QA flags shall be included for the granule or tile as a whole and for each scan, spatial element or bin, as appropriate for the product level.

5. VERSION 1 OPERATIONS REQUIREMENTS

5.1 Operations Definitions and Context

The overall context for the V1 Release of the MODIS SDP S/W is shown in Figure 5-1. As illustrated, certain parts are only produced at certain DAACs.

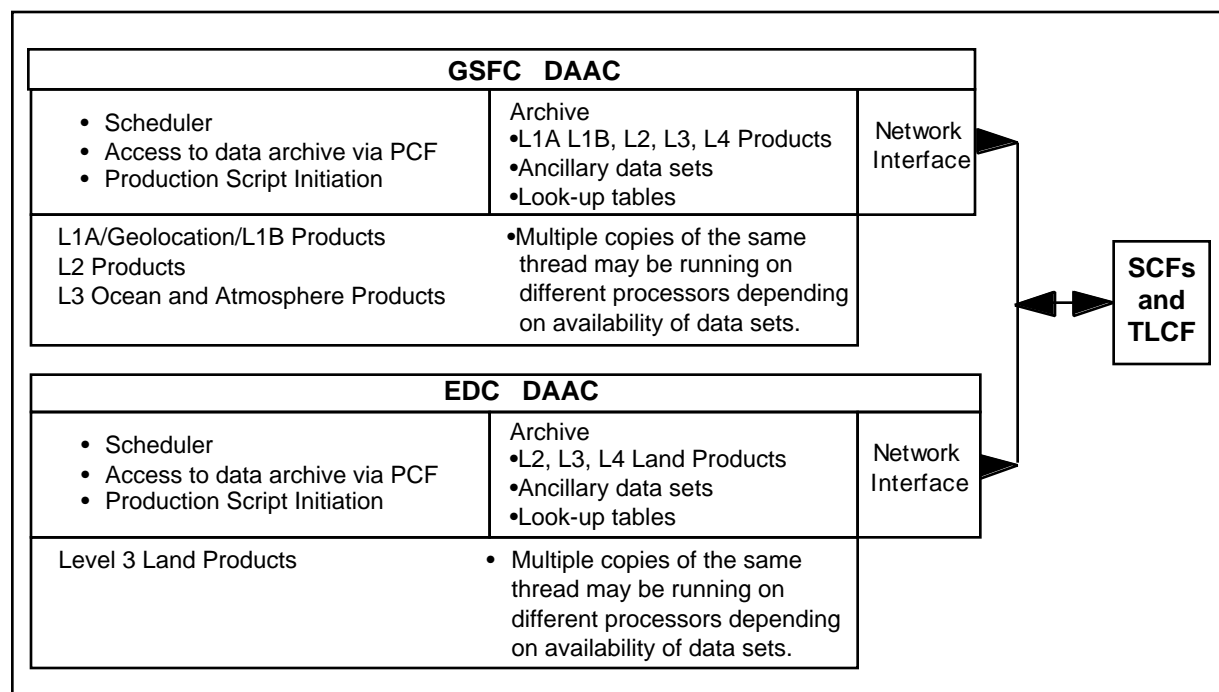


Figure 5-1 MODIS SDP S/W Context

The sequence of events shown in Figure 5-1 applies to a given MODIS PGE.

5.1-1 Deleted.

5.1-2 The V1 Release shall integrate all software processes available to the SDST software integration team into a SDP S/W system that executes all processes in the MODIS TLCF, and executes the processes in the GSFC DAAC, EDC DAAC, and the NSIDC DAAC (if available in Release A) as specified in Table 3-1.

5.2 Product Generation Executive Requirements

5.2-1 A PGE shall execute MODIS software processes within the ECS environment.

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APPENDIX A: ACRONYMS AND ABBREVIATIONS

CM	Configuration Management
CMO	Configuration Management Officer
DAAC	Distributed Active Archive Center
DAO	Data Assimilation Office
ECS	EOSDIS Core System
EDC	EROS Data Center
EOS	Earth Observing System
ESDIS	Earth Science Data and Information System
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
ICD	Interface Control Document
IFOV	Instantaneous Field-Of-View
L1	Level 1
L1A	Level 1A
L1B	Level 1B
L2	Level 2
L3	Level 3
L4	Level 4
LUT	Look-Up Table
M-API	MODIS Application Programming Interface
MCF	Metadata Configuration File
MCST	MODIS Characterization Support Team
MODIS	Moderate Resolution Imaging Spectroradiometer
NCSA	National Center for Supercomputing Applications
NMC	National Meteorological Center
NSIDC	National Snow and Ice Data Center
PCF	Process Control File
PGE	Product Generation Executive
QA	Quality Assurance
SCF	Science Computing Facility
SDP S/W	Science Data Production Software
SDPS	Science Data Processing Segment
SDPTK	Science Data Production Toolkit
SDS	Software Development Standards
SDST	Science Data Support Team
SGI	Silicon Graphics Inc.
SMF	Status Message Facility
SMP	Software Management Plan
SPSO	Science Processing Support Office

SSI&T	Science Software Integration and Test
SSTG	Science Software Transfer Group
STM	Science Team Member
TBD	To Be Determined
TBS	To Be Supplied
TLCF	Team Leader Computing Facility
TLWA	Team Leader Working Agreement
URL	Universal Resource Locator
V1	Version 1
V2	Version 2
WGS84	World Geodetic System 84